Final Report
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Project Title: Northern Yellow Bat Roost Selection and Fidelity in South Carolina

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Objective 1: Radio-track healthy Northern yellow bats (≤ 10) captured by mist netting appropriate habitat in spring, summer, and fall 2016, ideally with at least 3 radio-tracking events in each season. Record roost switching and describe roost sites selected.

Accomplishments:

Introduction: The primary purpose of this study was to investigate the roost site selection and fidelity of northern yellow bats (*Lasiurus intermedius*, syn. *Dasypterus intermedius*) by capturing, radio-tagging and tracking individual *L. intermedius* at Palmetto Bluff, a 15,000 acre, partially-developed tract in Beaufort County, South Carolina (Figures 1 and 2). Other objectives (2 and 3) were to obtain audio recordings of bats foraging in various habitats across the Palmetto Bluff property, including as many *L. intermedius* as possible and to initiate a public outreach program in order to educate the community on both the project and the environmental needs of bats, many of which are swiftly declining species in the United States.

Figure 1. Location of Palmetto Bluff

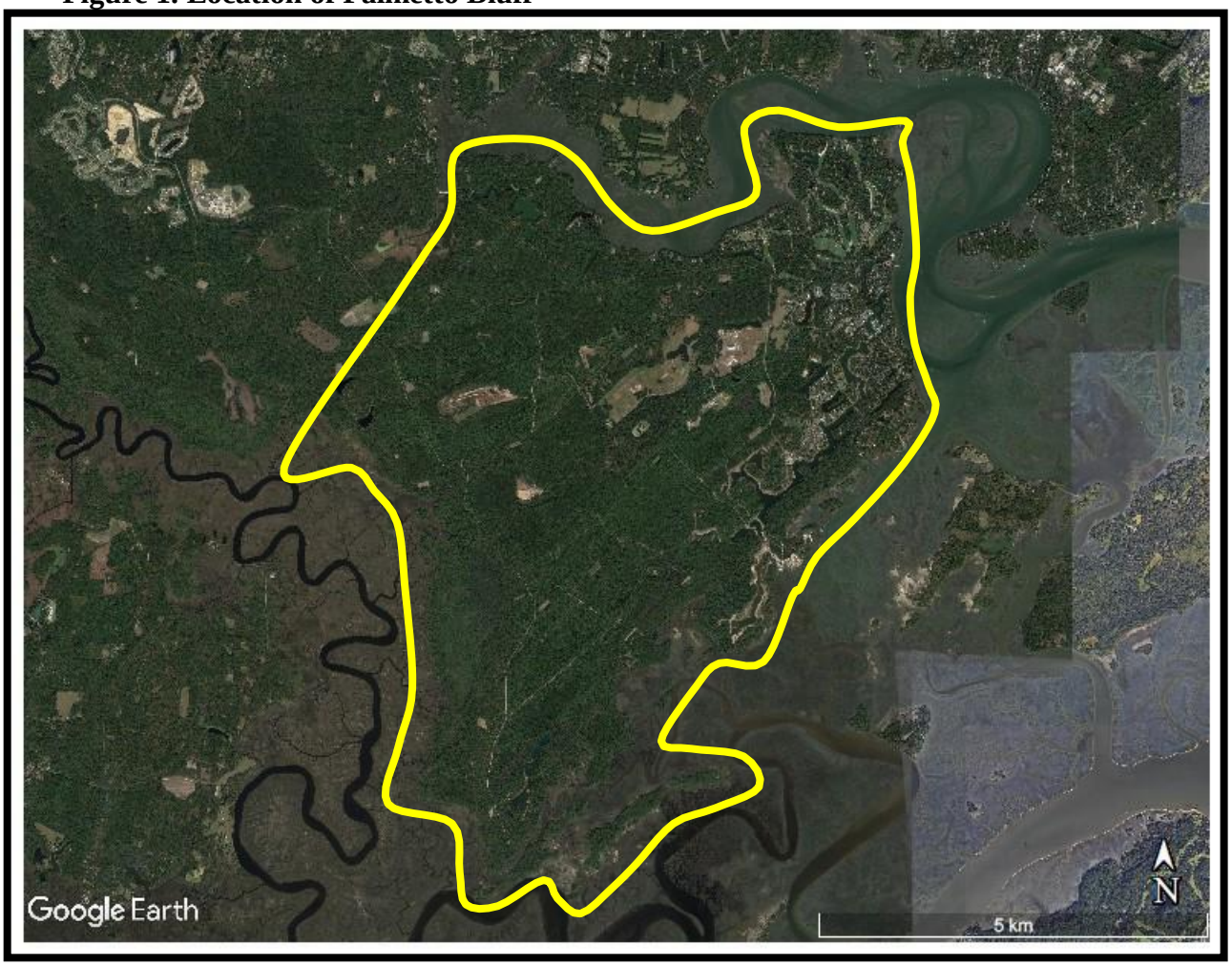


Figure 2. The Palmetto Bluff Development Tract

The life history of northern yellow bats, a high-priority species in the Southeast, is poorly understood. Studies in coastal Georgia found that all yellow bats that were tracked roosted in Spanish moss in southern live oaks (*Quercus virginiana*) and sand live oaks (*Quercus geminata*) (Coleman et al. 2012, Menzel et al. 1999). Spencer (1988) mentions northern and southern yellow bats (*L. ega*) sharing roosts in dead fronds of Washingtonia sp. palms, and Hutchinson (2006) found one northern yellow bat using a partially-dead sabal palm (*Sabal palmetto*) frond in central Florida. However, information on the behavior and habitat requirements of *L. intermedius* in relation to the coastal ecoregion of South Carolina is lacking.

Methods: Mist-netting took place from May 2016 through March 2017 (mist-netting was extended beyond the proposal dates of April 15, 2016 to February 28, 2017 because official grant approval was not received until June 6, 2016 [Piccirilli 2016], too late to achieve the netting goals in the spring of 2016). Our proposal included a projected minimum of 18 net nights in spring (1 March to 31 May), 60 in summer (1 June to 30 September), and 30 in fall/winter (1 October to 28 February). Actual netting began 25 May 2016 and ended 10 March 2017. Total net nights were significantly higher than planned. Our spring total was 44 net nights, eight of which took place in May 2016 and the remainder in March 2017. Summer net nights totaled 99, taking place between 7 June and 30 September 2016. Fall/winter net nights totaled 83, beginning 31 October 2016 and ending 20 January 2017. Between two and four nets were deployed at each trapping location, and nets were set at one or two sites each night.

Mist-netting was conducted at a variety of sites in developed and relatively undisturbed habitats at Palmetto Bluff in Beaufort County, South Carolina (Figure 3). Biologist Jason Robinson (Biological Systems Consultants, Inc.) headed the late summer, fall, winter, and spring mist-netting teams; Austin Trousdale, PhD, supervised the early and mid-summer mist-netting. Field assistants were Tom Wilson, Sam Freeze, Kellen McAuliffe, Shane Rahn, Tim White, Mary Socci, Justin Hardy, Lori Duncan and Brittany Hall.

Nets used were 50-denier, 38 mm-mesh mist nets measuring 2.6 m high and 6, 9, 12, or 18 m long. Nets were placed in likely flyways in areas adjacent to wetlands, ponds, fields, and forest (Figure 4). Multi-tier nets were used in some locations, stacking 2 or 3 of the 2.6 m nets for a total of 5.2 or 7.8 m height respectively. On each netting night, nets were deployed for a minimum of 3 hours after sunset.

Captured bats were weighed and sexed and forearm length was measured. Age was estimated based on epiphyseal-diaphyseal fusion in finger bones. Female reproductive status was classified as lactating, pregnant, or nonreproductive; adult males were classified as reproductive or nonreproductive.

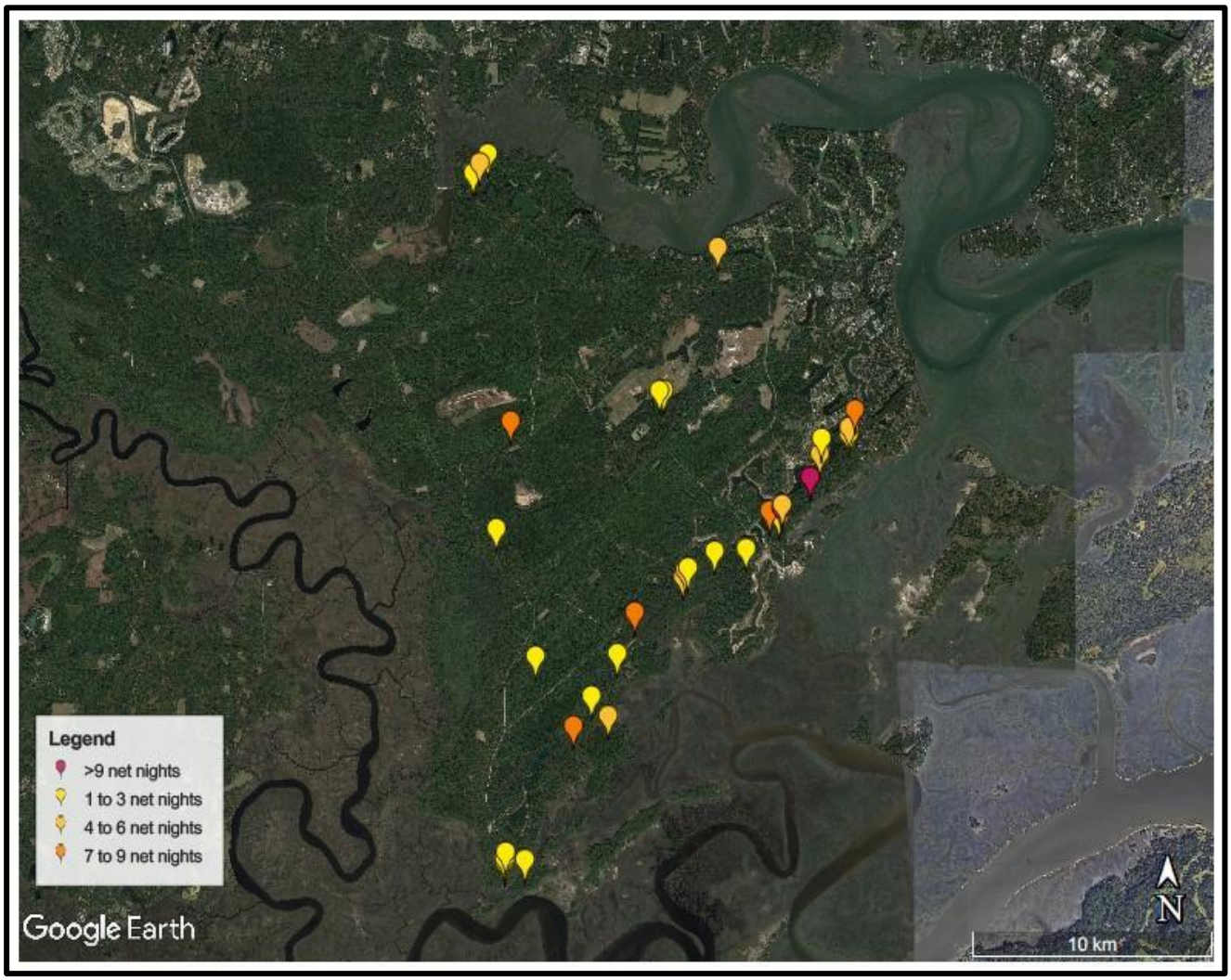


Figure 3. Netting locations at Palmetto Bluff

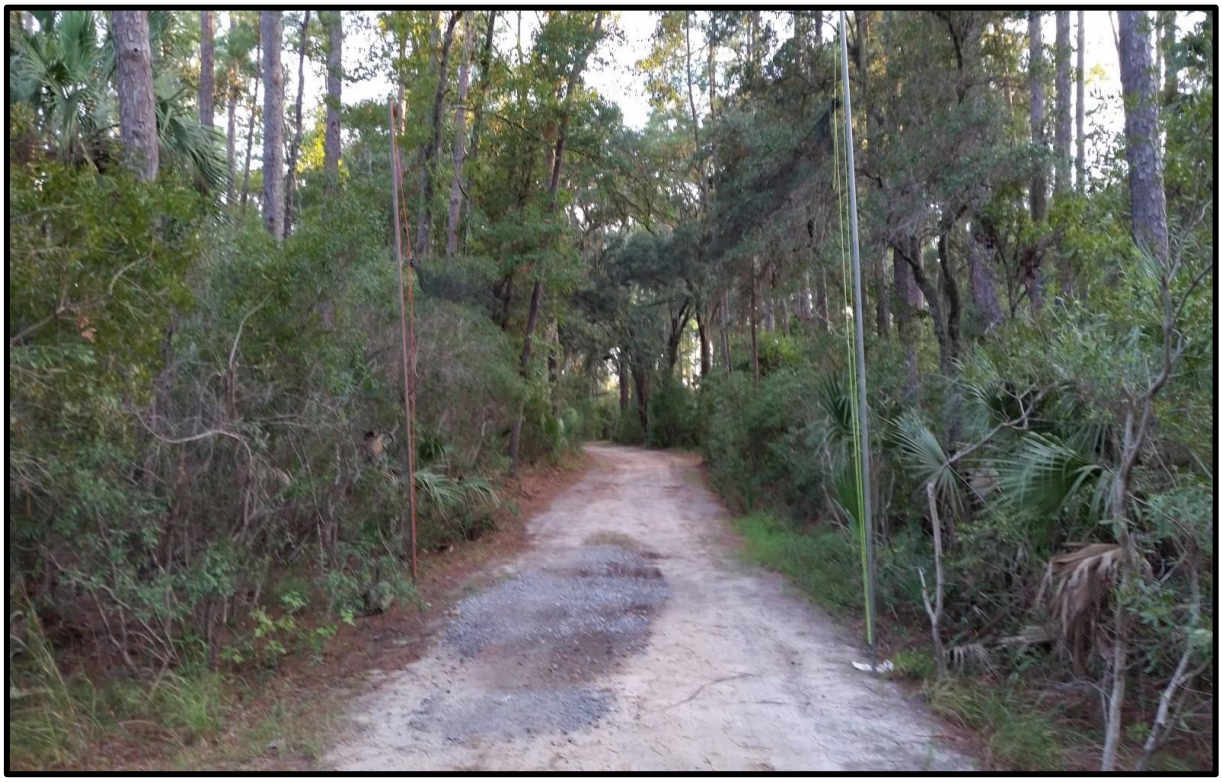


Figure 4. Typical net set (River Road Preserve)

Figure 5. Lasiurus intermedius 1 (LAIN 1)

Results: From May 2016 to October 2016, more than 90 bats were captured, but no *L. intermedius* were caught. The first *L. intermedius* capture occurred in November 2016 and two more were caught in March 2017. Transmitters were placed on these individuals and the bats were tracked until the transmitters failed. The tracking yielded new data on the behavior of *L. intermedius* in coastal environments and is discussed below.

Lasiurus intermedius 1 (LAIN 1)

On 3 November 2016, an adult male northern yellow bat (Figure 5) was captured at GPS coordinates 32.18303, -80.8917 (Figure 6), in the River Road Preserve, 145 acres of upland pine/hardwood forest owned by the Palmetto Bluff Conservancy and protected by a conservation easement. The bat was fitted with a metal band, numbered C0104, on its right forearm. A BD-2® radio transmitter (Holohil Inc.™, Carp, Ontario, Canada) was attached to the bat's back. The bat weighed 23 g, and the transmitter weighed 0.61 g (2.7% of the bat's body mass).

Beginning on 4 November, the bat was tracked to its roost site approximately 1.66 km from the capture location, using a model TRX 1000S® radio receiver (Wildlife Materials, Inc.,™ Carbondale, Illinois) and a 3-element yagi antenna. On 4 November, the bat was located approximately 5 m above ground on the underside of a folded dead frond of a sabal palm (*Sabal palmetto*), on the south side of the tree. (Figures 6, 7 and 8). The roost was in an upland pine habitat undergoing development and was on a residential lot where the understory and midstory had been cleared. The overstory at the site consists of live oak (*Quercus virginiana*), mature loblolly pine (*Pinus taeda*), mature slash pine (*Pinus elliottii*), and sabal palm. Nearby uncleared lots have a midstory of redbay (*Persea borbonia*), Chinese tallow tree (*Triadica sebifera*), naturally regenerated loblolly pine, and wax myrtle (*Morella cerifera;* formerly *Myrica cerifera*). The understory in the uncleared areas consists of wax myrtles, sabal palms, and partridge pea (*Chamaecrista fasciculata*).

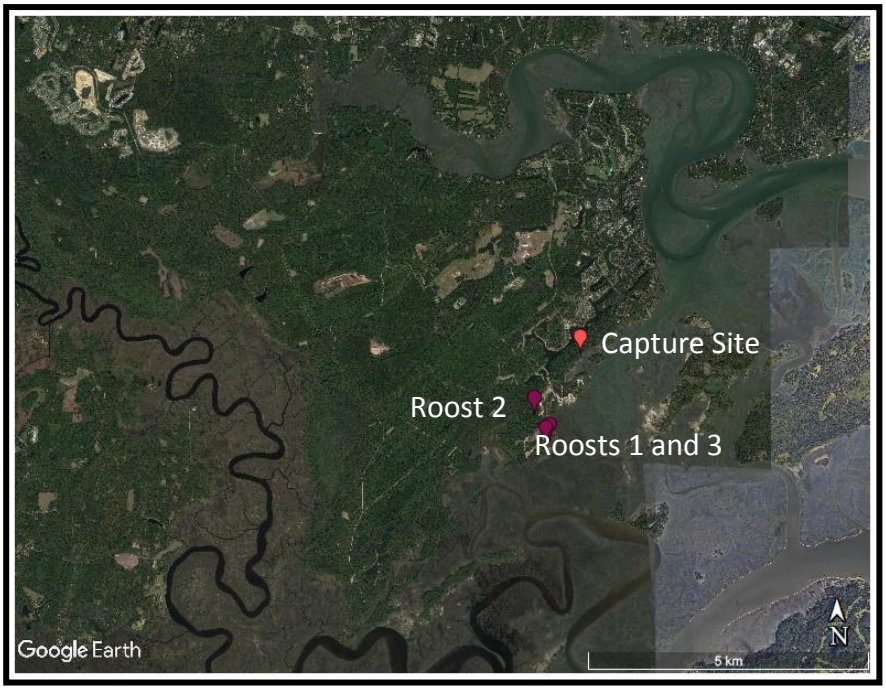
The evening following the capture, the bat was again located via radio transmitter, near the original capture location and moving actively, likely feeding. This was the only time that the bat was relocated after sunset.

From 4 to 11 November, the bat used the same roost. On 12 November, the bat moved to a second roost site located in an upland pine/mixed hardwood habitat in a large live oak that was heavily covered in Spanish moss (Figures 9 and 10). The overstory at the second roost site is comprised of mature loblolly pine, mature slash pine, live oak, laurel oak (*Quercus laurifolia*), water oak (*Quercus nigra*) and sweetgum (*Liquidamber styraciflua*). The midstory at the site is densely populated with naturally regenerating loblolly pine and slash pine. Redbay and wax myrtle are also present in the midstory. The understory consists primarily of wax myrtle, sabal palm, and sweetgum.

Although the bat was not visible from the ground, it is likely that it was hidden in a clump of Spanish moss, as this behavior has been well described (Coleman 2012) and was observed in the third *L. intermedius* captured at Palmetto Bluff (see below).

From 22 to 24 November, the bat roosted in a second palmetto, less than 100 meters from its first roost. Again, it used a dead palm frond on the southern side of the tree, although slightly higher at about 6m above ground level (Figures 11 and 12). This palmetto was in habitat identical to that of the first roost site but it was directly adjacent to an uncleared wetland.

During the period during which the transmitter was functioning, the bat remained consistent in its use of the three roost sites. After the transmitter's power was depleted, it appeared in the original sabal palm roost intermittently for several more weeks (it was impossible to visually confirm whether the bat continued to use the live oak roost site), with the last sighting on 12 December. On this date, the area around the roost tree was being mown; the roost site continued to be monitored but the bat did not return. Visual monitoring of the second sabal palm roost found no evidence of continued use.



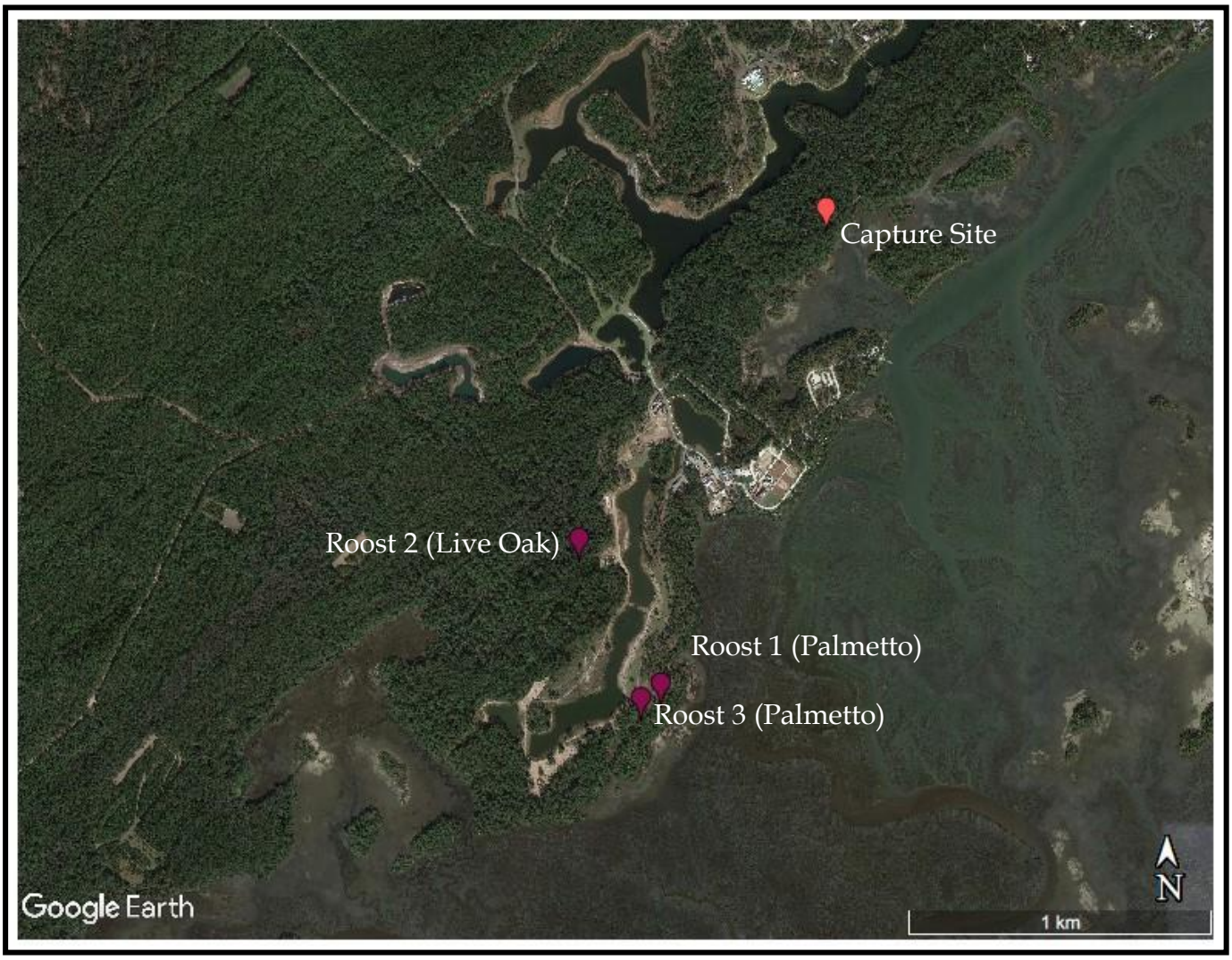


Figure 6. Capture and roost locations of LAIN 1

Figure 7. LAIN 1, roost 1

Figure 8. LAIN 1, roost 1

Figure 9. LAIN 1, roost 2

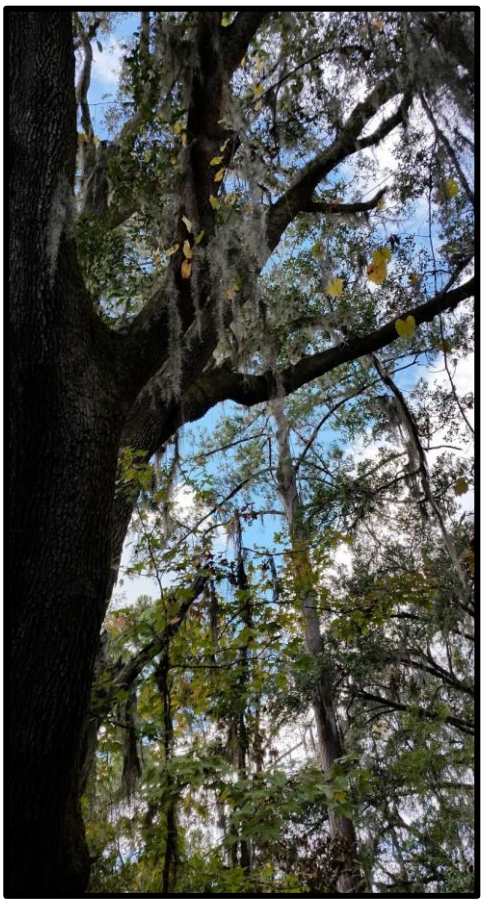


Figure 10. Spanish moss on live oak (roost 2)

Figure 11. Roost 1 and roost 3 of LAIN 1

Figure 12. LAIN 1 in dead leaf of roost 3

Both palmetto roost sites were located within 100 meters of a road, in mixed pine and hardwood secondary forest. The proximity of the palmetto roost sites to development suggests that northern yellow bats are able to make use of habitats associated with human disturbance. Both of these roosts were in dry, dead palm fronds, which are similar in color to the fur of northern yellow bats and therefore may have been chosen for the camouflage they provide. It follows that conservation efforts in developed areas may

benefit from encouraging land managers to avoid trimming the dry fronds from palms used in landscaping.

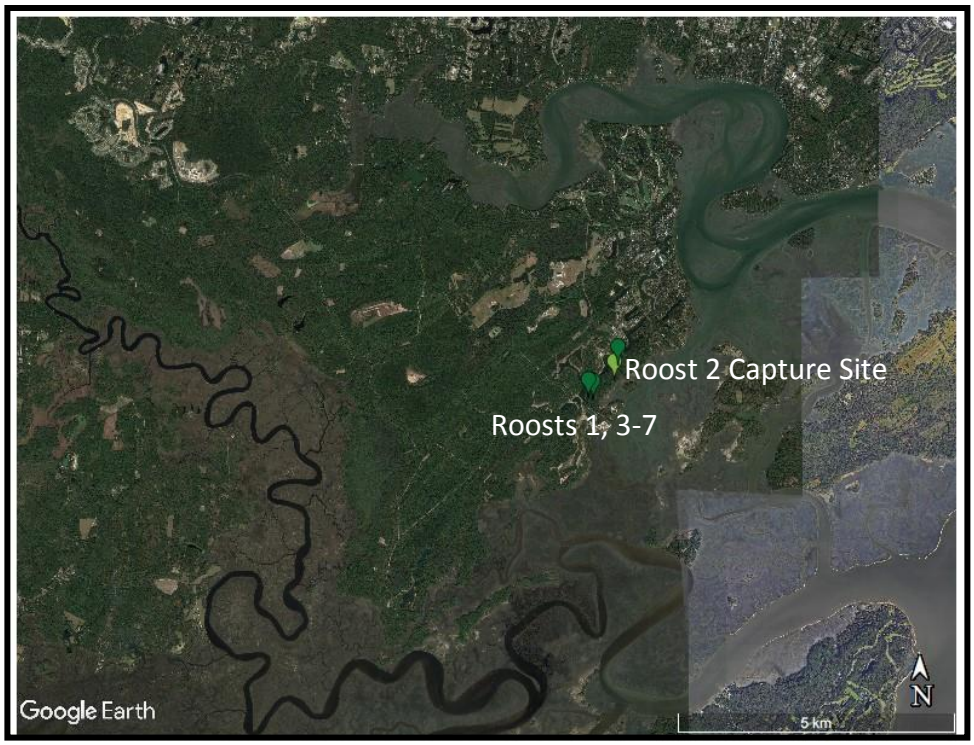
It is possible that the bats are sensitive to being disturbed at their roost sites, as the individual did not return to its roost after the area beneath it was mowed; however, other studies found roost switching to occur commonly (Menzel 1999) and it is possible that the bat would have moved even without the disturbance.

Details of the tracking of LAIN 1 and the other bats may be found in Appendix A.

Figure 13. LAIN 2

Lasiurus intermedius 2 (LAIN 2)

A second reproductive adult male *L. intermedius* (Figure 13), weighing 17g, was captured on 6 March 2017, in an upland pine and hardwood forest at GPS coordinates 32.18326, -80.8917, in a net 27 m from the location of the net that caught LAIN 1 in November 2016 (Figures 14 and 15). The bat was fitted with a metal band, numbered C0102 on its right forearm, and a transmitter, weighing 0.6 g (3.5% of the bat's body mass). The bat was then tracked using the same method as the first *L. intermedius*, and located at a total of 7 roost sites over the next three weeks (Figure 14). On the day following capture, it was also found to be feeding in the vicinity of the original capture location; it was not located feeding again after this date. During the six days following its capture (7 March through 12 March), the bat used a different roost each night. The sixth roost site was reused nightly for a total of five nights, from 12 March to 16 March 2017 during which time significantly colder temperatures impacted the area (highs ranged from 48°-60° F [9°-15° C] and night lows were 34°-51° F [1°-10° C]). The bat then moved to a seventh site, which it used for a minimum of 10 nights, from 17 March to 26 March; the last three days at this roost it was located visually, as the transmitter was no longer broadcasting a signal. On 27 March, the bat appeared to be present, but line of sight to its roost was obstructed and no unambiguous visual confirmation could be made. From 28 March to 1 April 2017, the seventh roost site and nearby roosts were checked daily, but the bat was not found.



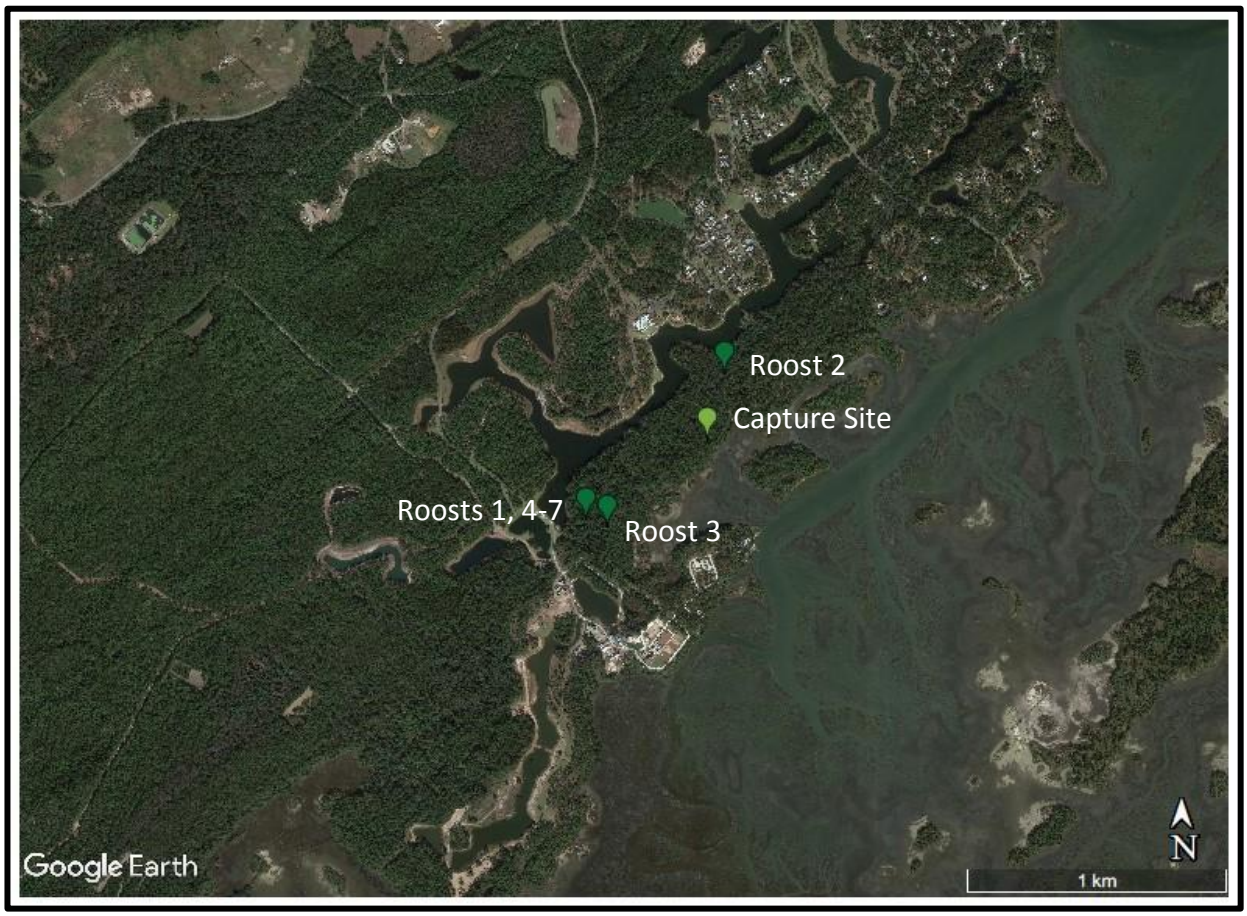


Figure 14. Capture and roost locations of LAIN 2

Figure 15. LAIN 1 and LAIN 2 capture locations and roosts

All seven of its roost sites were located 5 to 6 m high in dead fronds of sabal palms, in regenerating maritime forest adjacent to an evergreen wetland (Figures 16 and 17). Overstory at the roost sites consists of loblolly pine, live oak, sweetgum, sabal palm and water oak. Midstory is comprised of sporadic wax myrtles, abundant young sabal palms and swamp bay (*Persea palustris*). Southern waxy sedge (*Carex glaucescens*), cinnamon fern (*Osmundastrum cinnamomeum*), river cane (*Arundinaria gigantea*) and wax myrtle form the understory at the sites.

Unlike the first bat's palmetto roosts, the roosts of LAIN 2 were located on the northern or eastern sides of the palm trees despite colder weather. This may suggest that roost choice is not influenced by thermoregulatory concerns, as south-facing roosts would provide more consistent daytime sun.

Figure 16. LAIN 2 roost 1 (left) and roost 3 (right). These roosts are representative of the five other roost trees.

Figure 17. LAIN 2 in palmetto frond in roost 1. The band is visible on its forearm.

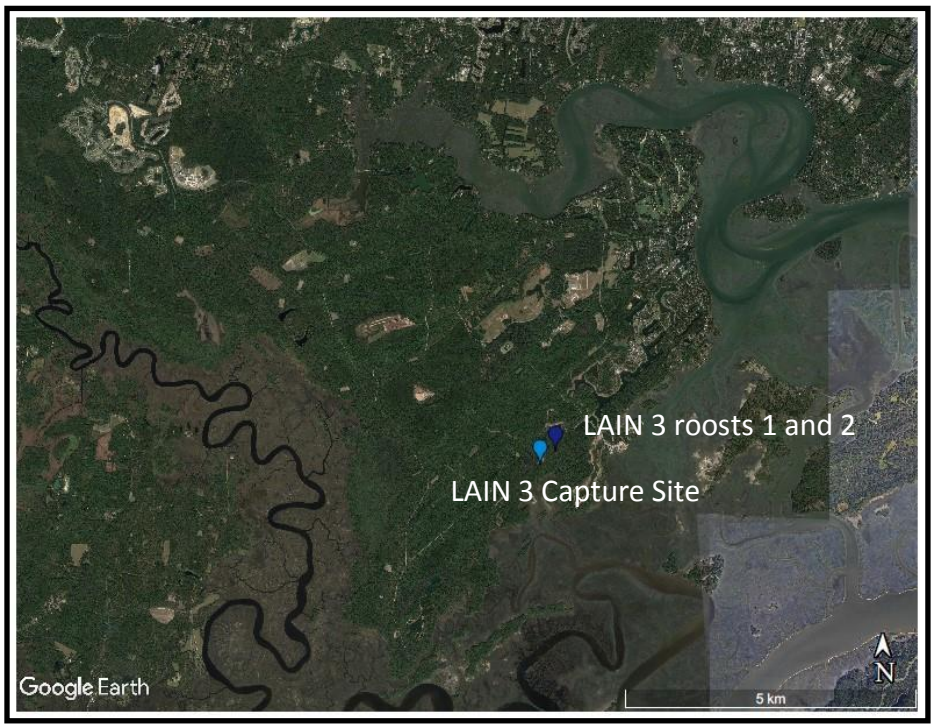
Figure 18. LAIN 3

Lasiurus intermedius 3 (LAIN 3)

A third reproductive adult male *L. intermedius* (Figure18), weighing 18 g, was captured on 9 March 2017, in mature maritime forest at GPS coordinates 32.17288, -80.9084 (Figure 19). The bat was banded on its right forearm with a metal band numbered C0103, and a transmitter weighing 0.6 g (3.3% of the bat's body mass). The bat was then tracked during the following 18 days, to a total of two roost sites. Unlike the other two bats, LAIN 3 roosted exclusively in clumps of Spanish moss, one in a water oak at a height of 5 m and the other in a loblolly pine at a height of 12 m (Figures 20 and 21). The two roosts are on an upland mixed pine and hardwood hill directly adjacent to a 25-year-old loblolly pine plantation. Overstory at the site consists of loblolly pine, water oak, laurel oak, and sweetgum. Wax myrtle dominates the midstory with an occasional sparkleberry (*Vaccinium arboreum*), common sweetleaf (*Symplocos tinctoria*), or sweetgum also present. The understory is made up of wax myrtle, sweetgum, sabal palm, common sweetleaf, Virginia sweetspire (*Itea virginica*) and Carolina indigo (*Indigofera caroliniana*).

LAIN 3 switched roosts only twice, on 11 March and 13 March, between the two trees, which were approximately 7 m apart. The bat could not be located visually in the pine tree, however, on 19 March 2017, a small hole appeared in the Spanish moss of the oak tree and the bat could be seen roosting inside the clump of moss (Figures 22 and 23). The hole may have been made when the bat emerged or reentered its roost site the previous night after several nights of inactivity. The previous day had marked the end of a week-long cold spell during which the daytime highs ranged from 48°-60° F (9°-15° C) and night lows were 34°-51° F (1°-11° C). On 18 March, temperatures reached 75° F (24° C) during the day and that night, LAIN 3 may have taken advantage of the warmer temperatures and resultant increased insect activity to feed.

Although its transmitter failed on 23 March 2017, perhaps due to unusually cold temperatures, it was possible to visually confirm the location of the bat in the Spanish moss in the oak tree for five days after the radio signal ended. It may have continued to use the same roost after that time, but it could no longer be seen by researchers.



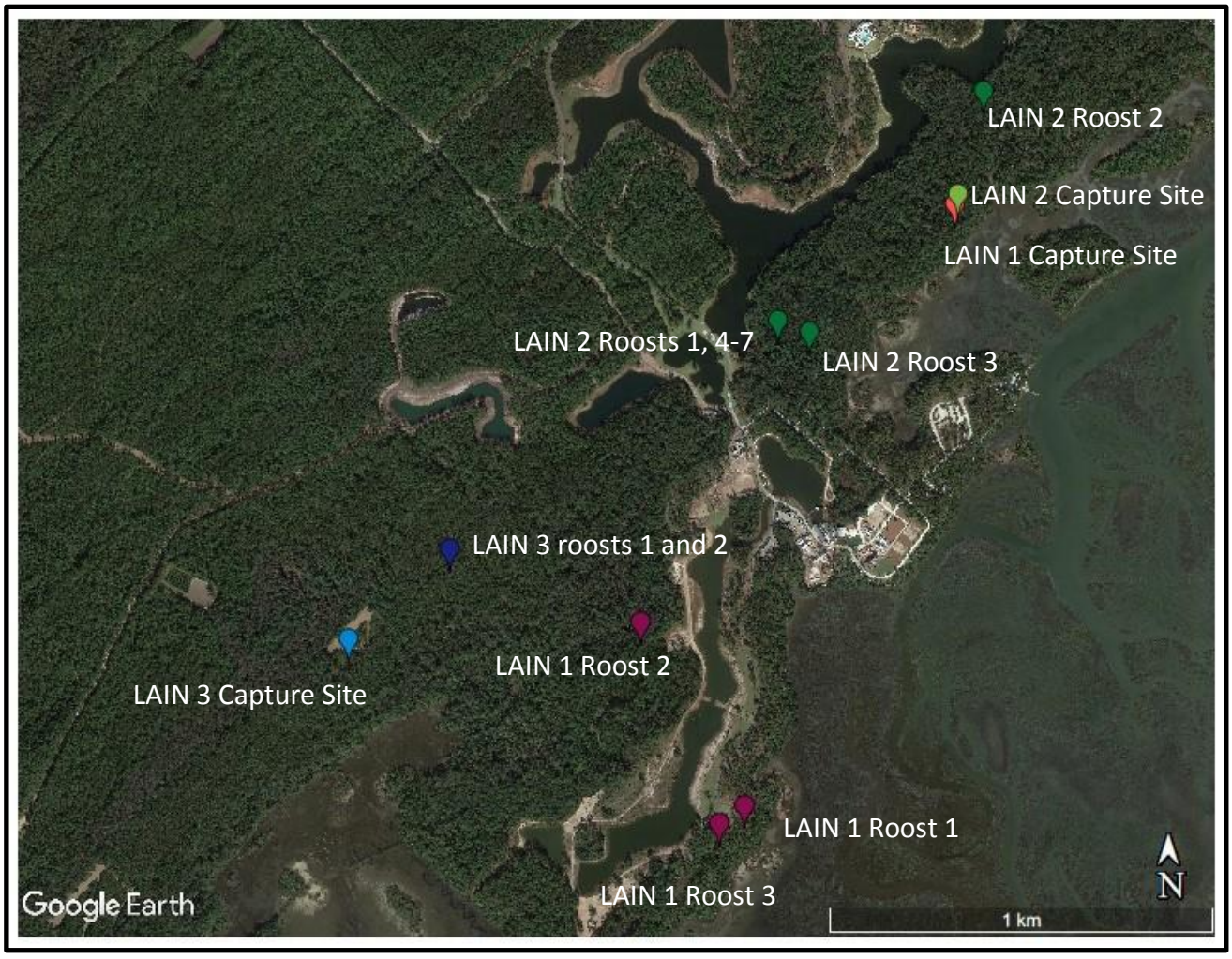


Figure 19. LAIN 1, 2 and 3 capture location and roosts

Figure 20. LAIN 3 roost 1

Figure 21. LAIN 3 roost 2

Figure 23. LAIN 3 roost 1

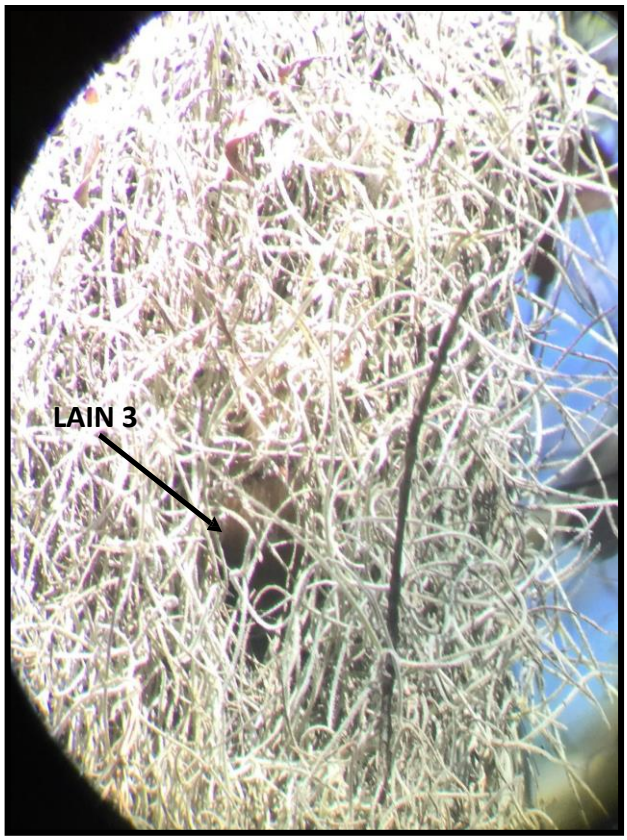


Figure 22. LAIN 3 roost 1

Lasiurus intermedius roost selection and fidelity

Menzel, et al. (1999), found that all roost sites (n=5) for a single male northern yellow bat were at least 10 m above the ground, while Hutchinson (2006) found that maternity roost sites (n=5) averaged only 2.23 m above ground; both studies described roosts with little to no clutter below, providing clear flight paths to and from the roost sites. All three bats tagged in this study were found roosting between 5.5 and 7 m above the ground, with the exception of one of bat LAIN 3's roost sites, located in Spanish moss approximately 12 m high.

Roost fidelity was calculated with the Shannon Index, which quantifies the diversity and evenness of roosts used:

$$H = -\sum_{i=1}^{n} p_i \ln p_i$$

where ***pi*** refers to the proportion of total roost nights spent at roost ***i.*** Therefore, a large number of roosts, each used only a small fraction of the time, produces a large ***H*** value, while a smaller number of roosts, with most spent in one location, produces a smaller ***H*** value. Results are shown in Table 1.

The higher Shannon Index of LAIN 2 indicates it was the least consistent in its use of roost sites: it used seven distinct locations, whereas the other two individuals used only two or three roosts. The causes behind its unpredictable roosting behavior are unclear, but perhaps the stress of its capture and release caused it to switch roosts rapidly for a few days, before settling into a steadier roosting pattern.

	LAIN 1	**LAIN 2**	**LAIN 3**
Band Number	**C0104**	**C0102**	**C0103**
Location	**32.18303, -80.8917**	**30.18326, -80.8917**	**32.17288, -80.9084**
Sex	**Male**	**Male**	**Male**
Age	**Adult**	**Adult**	**Adult**
Reproductive Status	**Reproductive**	**Reproductive**	**Reproductive**
Weight	**23.0 g**	**17.0 g**	**18.0 g**
# of days located	**23**	**20**	**18**
# of roost sites	**3**	**7**	**2**
# of roost switches	**5**	**6**	**2**
Mean duration at each roost	**3.833 ± 2.927**	**2.714 ± 2.914**	**6.0 ± 5.657**
Mean freq. of roost switching	**4.6**	**3.333**	**9.0**
Shannon Index	**0.8417**	**1.480**	**0.6837**

Table 1. Roost switching of tagged *L. intermedius*

Lasiurus intermedius range

For the first *L. intermedius* (LAIN 1), distance from the roost to the nightly foraging location was determined on the night of capture (3 November 2016) and the following night (4 November 2016) and was found to be approximately 1660 m. The distance from capture site to first roost site for the LAIN 2 was approximately 550 m, and the second roost site was 785 m from the first. The distance from capture site to first roost site for the bat marked LAIN 3 was approximately 350 m, and the two roost sites were very close together (<20 m).

These results are in contrast to Krishon et al. (1997), who described an average home range of 10.5 ha and an average distance from roost site to foraging location of 109 m. Because we did not track bats to their foraging areas on a regular basis, we did not estimate home range, however it is likely significantly larger than the previous estimate. In addition, LAIN 1 and LAIN 2 were captured in nets located approximately 27 m apart indicating that these two bats shared a feeding area while LAIN 2 and LAIN 3 were found roosting approximately 1000 m apart, suggesting that their territories may be adjacent, or even overlap.

The locations of all three *L. intermedius* captures and roosts are shown in Figure 15, illustrating the spatial relationship between their ranges. Each bat seemed to associate closely with a roost area, although they often chose several different roosts within that area. The bats' home ranges encompassed a wide area within Palmetto Bluff, and they made use of at least three tree species, sabal palm, live oak, and loblolly pine in addition to Spanish moss, indicating an association with several keystone species of the maritime forest.

Other species

During the study, a total of 115 other bats were captured, measured, and released. The majority of these were Seminole bats (*Lasiurus seminolus*), big brown bats (*Eptesicus fuscus*), and evening bats (*Nycticeius humeralis*). Tricolored bats (*Perimyotis subflavus*) and eastern red bats (*Lasiurus borealis*) comprised lesser numbers. (A tricolored bat captured on 10 March 2017 was swabbed and the sample sent for testing for *Pseudogymnoascus destructans*, the fungus that causes white-nose syndrome. The test was negative [M. Bunch, personal communication, 12 April 2017].) Two southeastern myotis (*Myotis austroriparius*), a species of special concern, and two northern long-eared bats (*Myotis septentrionalis*), a species listed as federally threatened were also trapped and banded. Full results are shown in Table 2 and the two myotis species are discussed in more detail below.

Species	# unique captures
Lasiurus seminolus	47
Eptesicus fuscus	36
Nycticeius humeralis	24
Perimyotis subflavus	12
Lasiurus borealis	6
*Lasiurus intermedius**	3
*Myotis austroriparius**	2
Myotis septentrionalis	2

Table 2. Captures of each species. An asterisk (*) denotes species that had transmitters attached and were tracked. All *Lasiurus intermedius, Myotis austroriparius,* and *Myotis septentrionalis* were also banded.

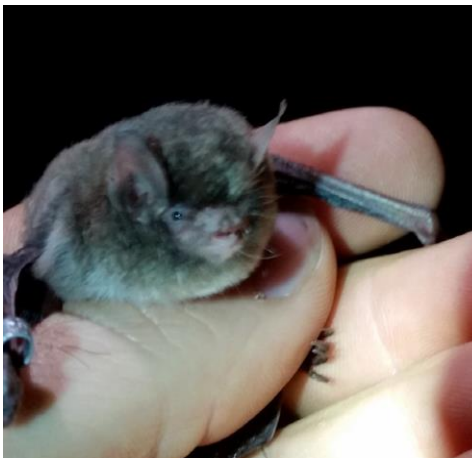


Figure 24. Southeastern myotis (*Myotis austroriparius*)

Myotis austroriparius (MYAU)

Two southeastern myotis (*Myotis austroriparius*), a species of special concern, were also trapped and banded. The first, a reproductive adult male (Figure 24), was caught on 28 September 2016 at GPS coordinates 32.179295, -80.895543, and weighed 6.25 grams. It was tagged with a transmitter identical to those used on the *L. intermedius*, and tracked for the next six days. It roosted all six nights in a sweetgum (*Liquidambar styraciflua*), in a cavity accessed by a hole near the base of the tree (Figures 25 and 26). Tracking was interrupted prematurely on the seventh day, due to the approach of Hurricane Matthew, which severely impacted the region and forced the research team to evacuate inland for safety. After returning on 12 October, debris from the hurricane made the site inaccessible. On 17 October, tracking resumed but no signal could be found. The original sweetgum roost site was undamaged by the storm, so it is possible that the bat continued to use it; no visual confirmation could be made.

The second *M. austroriparius*, a nonreproductive adult female, was captured on 4 November 2016. It was not fitted with a transmitter, because tracking had just begun for an adult *Lasiurus intermedius*, which was the primary focus of our research.

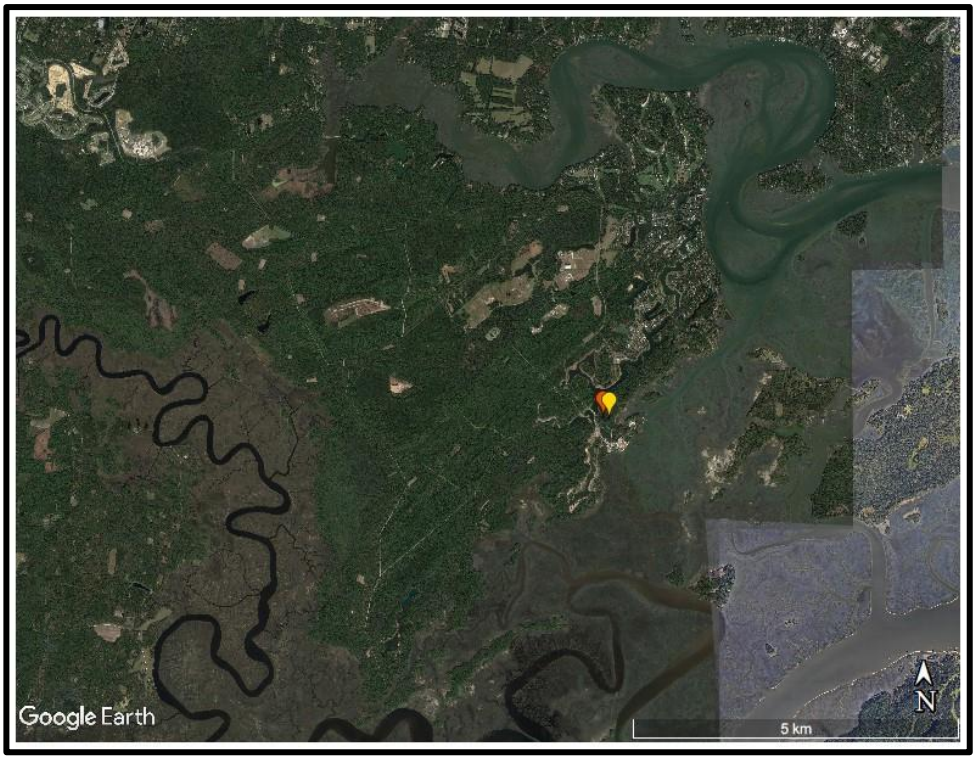


Figure 25. Southeastern myotis (*Myotis austroriparius)* capture location and roost

Figure 26. Sweetgum roost tree (left), and hole at base of roost tree (right).

Figure 27. Northern long-eared bats (*Myotis septentrionalis*). MYSE 1 shown on the left, MYSE 2 on the right.

Myotis septentrionalis (MYSE)

Of particular interest were two northern long-eared bats (*Myotis septentrionalis*), one female (MYSE 1) and one male (MYSE 2), captured in November 2016 (Figure 27). The first bat, a female, was caught on 3 November 2016 on the same day and in the same net as the LAIN 1 capture (Figure 28). Band B0462 was placed on the forearm and because the capture of a northern long-eared bat was so unexpected, a hair sample and fecal sample were sent to the *Species from Feces* program at the Bat Ecology & Genetics Lab at the School of Forestry, Northern Arizona University. The identification was confirmed two weeks later via DNA testing of the hair sample (Appendix B).

The second northern long-eared bat was caught on 14 November 2016 in a net at the same location as the first capture of an individual of this species. The second bat, banded B0495, was a male without total epiphyseal joint fusion, suggesting an individual born in the 2016 reproductive season. Although samples of fur and feces were again collected, the samples were too small to yield results. However, the DNA confirmation of the identification of the female *M. septentrionalis* caught 11 days earlier made the misidentification of the second bat unlikely. Researchers did not track the northern long-eared bats because transmitters on hand were too large for this species.

Northern long-eared bats are a species particularly impacted by white-nose fungus (*Pseudogymnoascus destructans)* infection, and are considered a threatened species under the Endangered Species Act. Traditionally considered a species found from the southern Blue Ridge through the northeastern US and into Canada (Menzel 2003), these captures represent unprecedented extralimital occurrences, possibly suggesting unrecognized coastal populations. Further investigation of potential undiscovered populations of this imperiled species may be warranted.

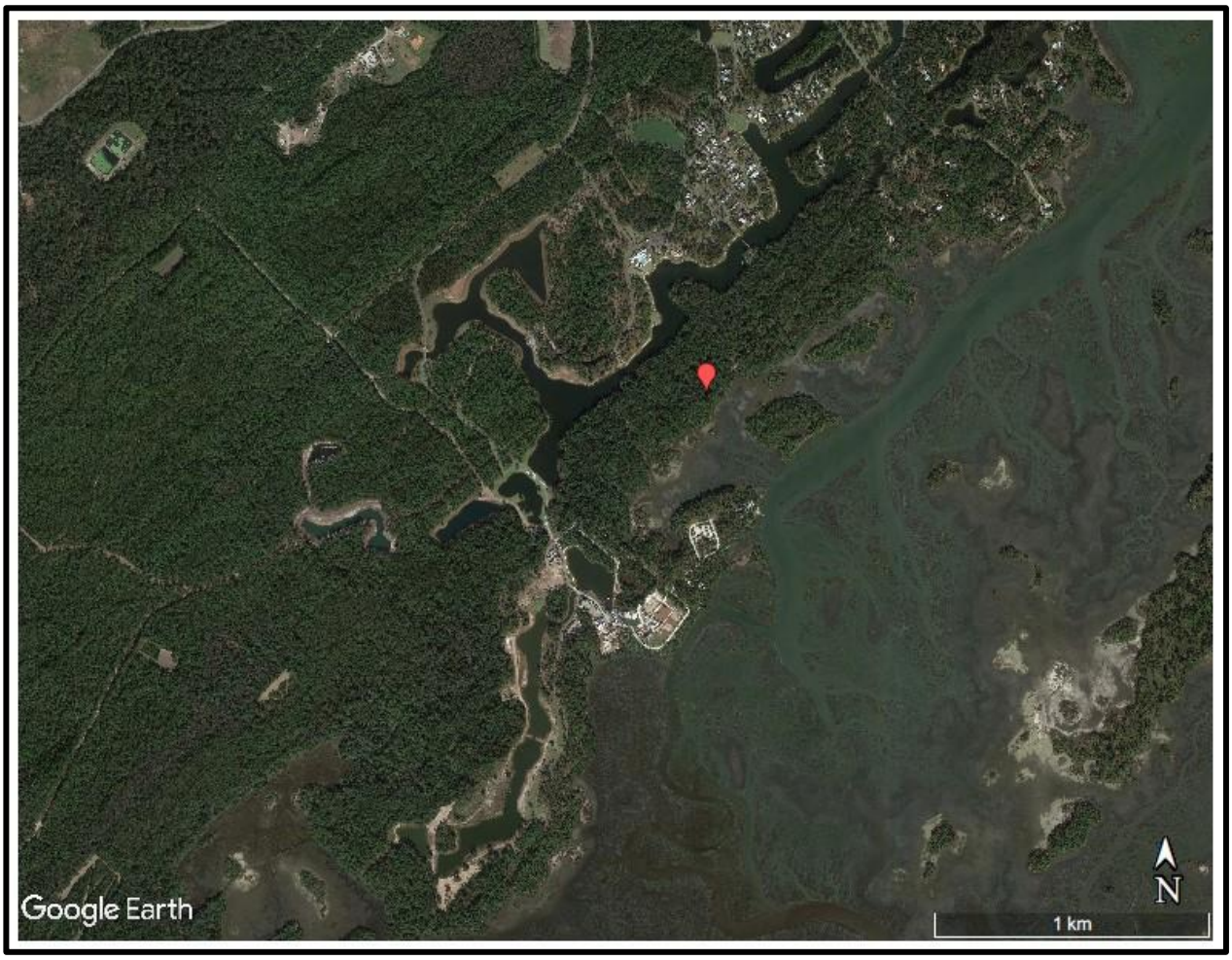


Figure 28. Capture site of two northern long-eared bats (*Myotis septentrionalis*)

Discussion: During the 2016-2017 study year, we captured 118 bats, and tracked three northern yellow bats (*Lasiurus intermedius*). Among the bats captured were two *Myotis* species, *M. austroriparius* and *M. septentrionalis*, both of which are of global conservation concern. All three *L. intermedius* were tracked to their roost sites for a minimum of 18 nights, and location fidelity was found to be high, though fidelity to individual roosts was lower. Roosting in *Sabal palmetto* fronds was a previously underappreciated behavioral feature, and represents a significant divergence from the prior assumed habit of using Spanish moss roost sites, although we confirmed that Spanish moss is also used.

Significant deviations: None

Objective 2: Collect acoustic data including recordings of Northern yellow bats for a shared call library. This effort will support our bat monitoring at Palmetto Bluff and it will assist another ongoing federally-funded Carolinas Acoustic Bat Surveys project.

Accomplishments:

Our objective was to place an Anabat Express bat detector in likely foraging locations (Figures 29 and 30) around Palmetto Bluff for a total of two nights in the spring (March to May), six in summer (June to September), and three in fall/winter (October to February). We were able to record only twice in the spring, but >15 times in summer and 10 times in the fall; all results are provided as supplemental data, but we will limit discussion to the two spring, six summer, and three fall dates.

After recording, thanks to additional support from the SCDNR and Biological Systems Consultants, Inc., sound files were processed using BCID automatic identification software instead of EchoClass (some reviewers have found BCID is preferable to the more conservative EchoClass for large numbers of calls and a complex species set [Tyburec 2014]). The following filters were used to eliminate isolated or few pulses and calls where identifications were more uncertain:

Minimum # Pulses Passing Filter =	*5*
Minimum Discriminant Probability =	*0.35*
Minimum Species Percent for ID =	*30%*
Minimum Group Percent for ID =	*20%*

Because northern yellow bats are a relatively unknown species, the software was unable to correctly label calls produced by *L. intermedius*. However, manual inspection of call spectrogram files revealed that the BCID software may have mis-categorized some *L. intermedius* calls as those of a similarly-sized lasiurine species, the silver-haired bat (*Lasionycteris noctivagans*). The two species are known to have some overlap in frequency and the two share similar patterns of individual calls; however, *L. noctivagans* is not known to occur in summer in coastal South Carolina, and spectrograms of *L. intermedius* calls are easily distinguished visually when a series of calls is obtained. Review of many of the summer *L. noctivagans* calls and a sample of the calls marked unidentified by BCID showed *L. intermedius* to be present at numerous recording sites.

Recordings on six nights in November 2016 included calls that BCID classified as *M. septentrionalis*, a finding that is consistent with the unexpected captures of that species.

Analysis of calls during each season showed differing nightly activity patterns. In spring, bat activity (measured in number of distinct call series) was characterized by a bimodal distribution, with a small peak just after dusk, and a larger peak just before dawn. In summer, feeding activity occurred

irregularly throughout the night, without visible trends. In fall, activity reached a peak immediately after sunset and tapered off swiftly, with nearly all recordings falling in the first three hours after nightfall. These results are shown in Figure 31-33.

Overall, our acoustic monitoring showed differing nightly activity patterns during spring, summer, and fall/winter seasons, and revealed the presence of *L. intermedius* at widely varying locations and habitats across the study area.

Originally, we intended to obtain recordings of northern yellow bat search-phase calls, using a light-tagged individual and a directional microphone. However, we were unable to do so with the three bats we captured. This will remain a goal in continuations of the study.

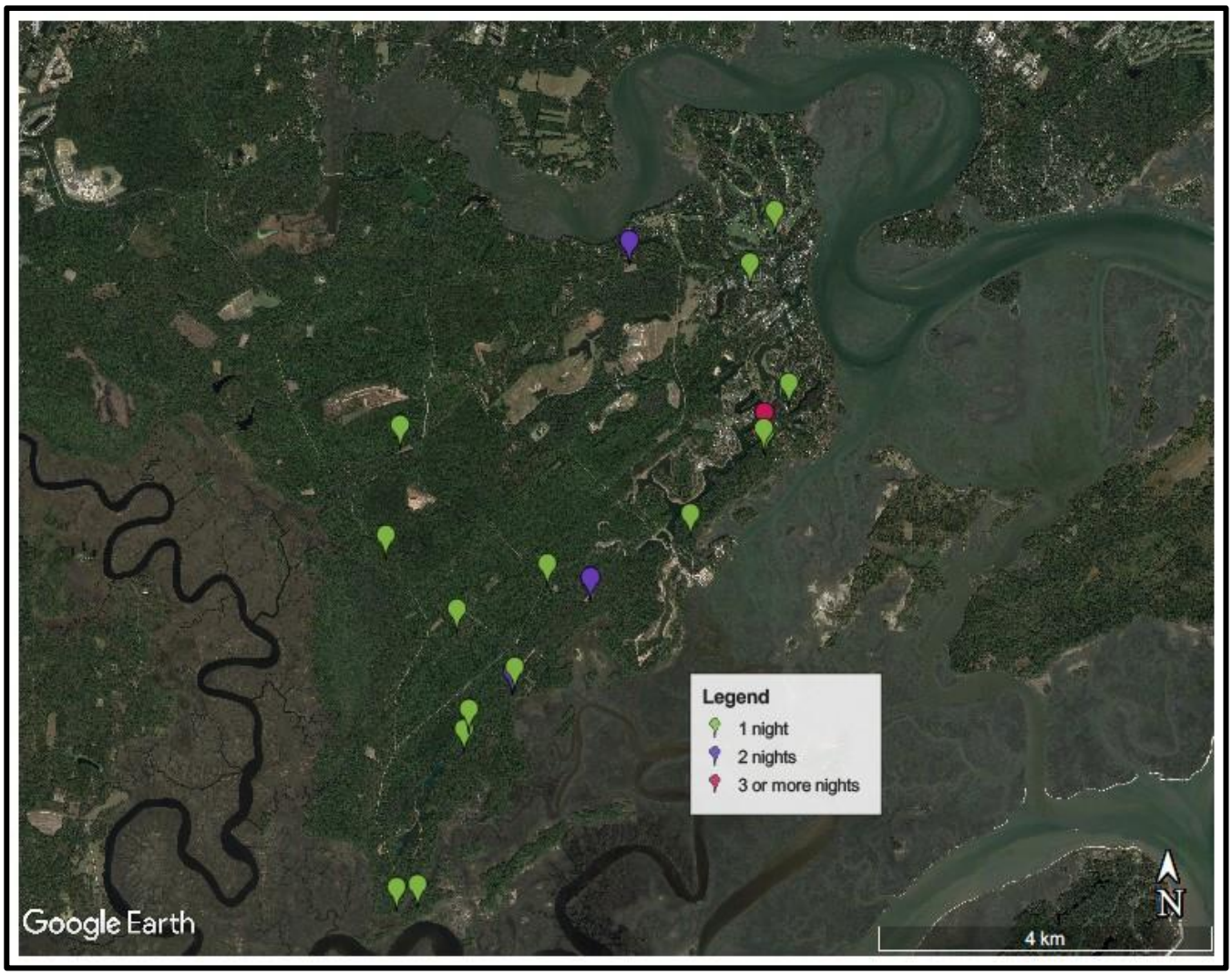


Figure 29. Anabat Express deployment sites and number of nights at each site

Figure 30. Deployed Anabat Express

Significant deviations: We were unable to record Northern yellow bats when released using a directional microphone for a shared call library. However, this will remain a goal of the study as it continues through other sources of funding.

Objective 3: Outreach within and around Palmetto Bluff to encourage residents and visitors to tolerate and manage for bats.

Accomplishments:

The third objective of the project was to provide information to the public about the ecology of bats in the Lowcountry. Conservancy researchers gave over a dozen presentations on the study at Palmetto Bluff to a total of over 200 people. Several members of the community joined researchers as they tracked the northern yellow bats and the Island Packet, the local newspaper, provided print, video and online coverage of the discovery of the northern long-eared bats. In addition, a Beaufort High School student used the acoustic data from the Anabat Express for a science fair project titled "Listening For Differences" and won the Sea Island Science Fair in March 2017 and went on to compete at the Intel International Science Fair in Los Angeles in May 2017 (Figure 34).

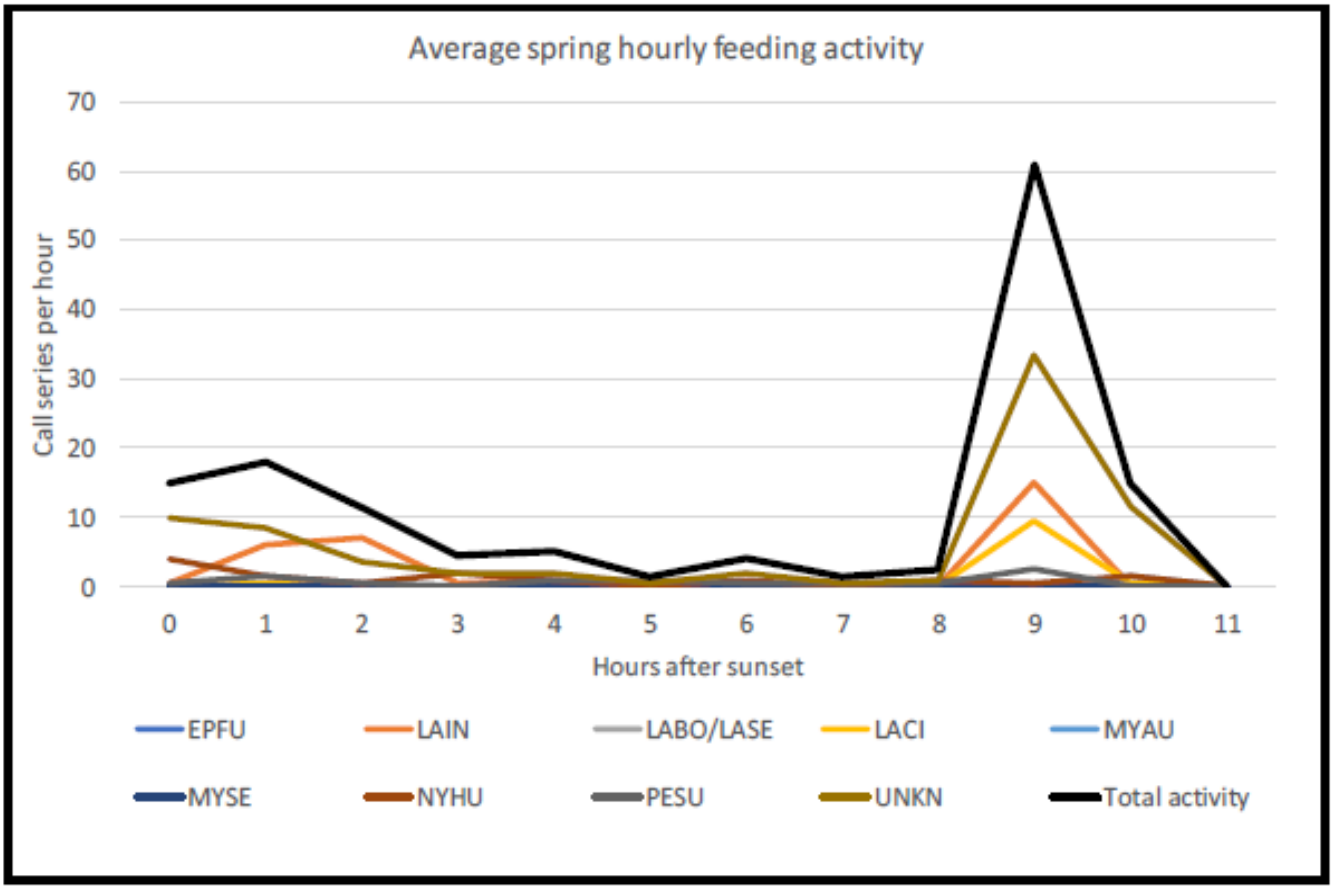


Figure 31. Average spring hourly feeding activity. Two distinct activity peaks are visible: one immediately after sunset and one preceding sunrise.

Species key:

EPFU: *Eptesicus fuscus,* Big Brown Bat

LANO: *Lasionycteris noctivagans,* Silver-haired Bat

LAIN: *Lasiurus intermedius,* Northern Yellow Bat

LABO: *Lasiurus borealis,* Eastern Red Bat

LACI: *Lasiurus cinereus,* Hoary Bat

MYAU: *Myotis austroriparius,* Southeastern Myotis

MYLU: *Myotis lucifugus,* Little Brown Bat

MYSE: *Myotis septentrionalis,* Northern Long-eared Bat

NYHU: *Nycticeius humeralis,* Evening Bat

PESU: *Perimyotis subflavus,* Tricolored Bat

UNKN: not identified by BCID software

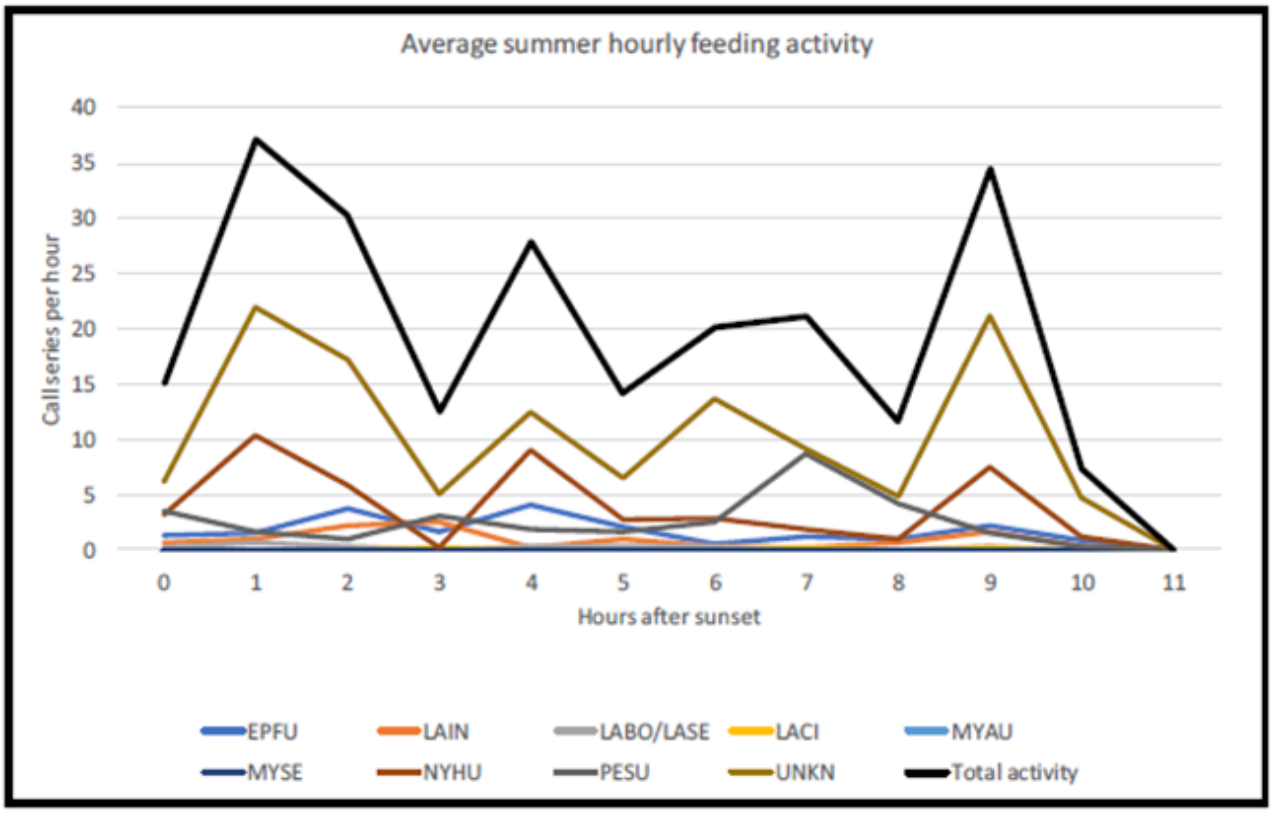


Figure 32. Average summer hourly feeding activity. Feeding continues throughout the night, with largest peaks after sunset and before dawn.

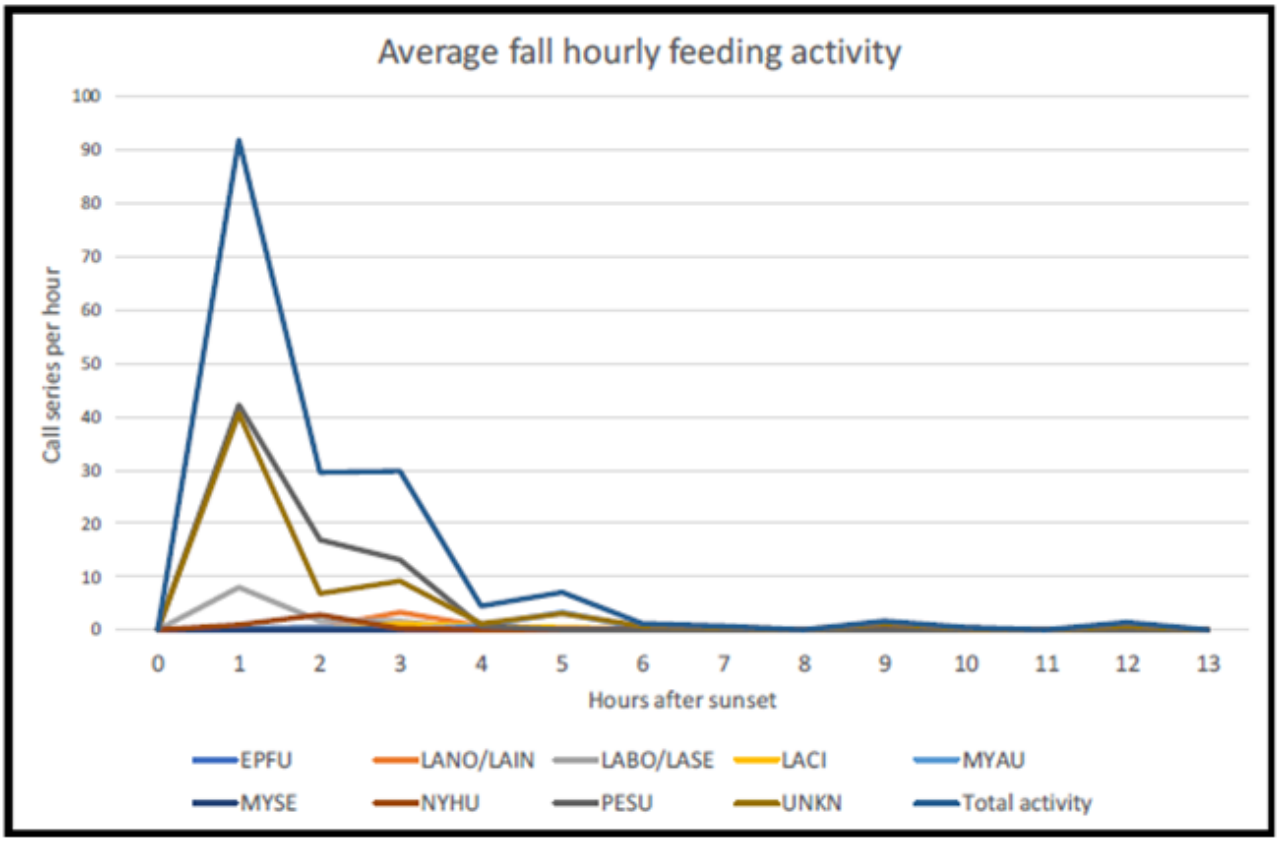


Figure 33. Average fall hourly feeding activity. Nearly all activity occurs within three hours of sunset, and tapers off swiftly. No second peak is noted.

http://www.islandpacket.com/news/local/news-columns-blogs/untamed-lowcountry/article128269194.html

Figure 34. Community outreach included presentations (top), local media interviews and articles (middle), engaging high school students in research (bottom).

Significant deviations: None

Total Cost: $15,000

Recommendations:

In future study seasons, we plan to track more individual northern yellow bats, hopefully including females and immatures, in order to better understand their roosting and foraging habits. We will also further investigate the unprecedented captures of *Myotis septentrionalis*, which constitute important extralimital occurrences and which may suggest the need for conservation efforts in coastal regions. Acoustic recording will continue, in order to quantify the bat species using Palmetto Bluff's varied habitats as foraging grounds. Finally, community education efforts will also continue, in order to encourage property owners and visitors to ensure that they coexist with bats in an ecologically friendly manner.

Submitted by: Mary Socci and Jennifer Kindel

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Appendix A

Roost Data

LAIN 1 Roost Sites					
Date	**Lat**	**Long**	**Observation time**	**Roost #**	**Notes**
11/4/2016	32.168985	-80.897506		1	dead frond, sabal palmetto (one of the smaller ones in this location), same frond each day, cleared understory, palmetto/pine tree cover, marsh edge
11/5/2016	32.168985	-80.897506	10:22	1	same dead frond
11/6/2016	32.168985	-80.897506	15:31	1	same dead frond
11/7/2016	32.168985	-80.897506	12:39	1	same dead frond
11/8/2016	32.168985	-80.897506	9:45	1	same dead frond
11/9/2016	32.168985	-80.897506	15:49	1	same dead frond
11/10/2016	32.168985	-80.897506	9:11	1	same dead frond
11/11/2016	32.168985	-80.897506	10:04	1	same dead frond
11/12/2016		not located		2	signal from the vicinity of 11/14/2016 location, likely the same tree
11/13/2016					no tracking
11/14/2016	32.173268	-80.900371	14:00	2	large live oak with dense Spanish moss
11/15/2016	32.173268	-80.900371	15:00	2	emergence count conducted 1700-2100. No bats observed.
11/16/2016	32.173268	-80.900371	11:30	2	
11/17/2016	32.173268	-80.900371	14:00	2	
11/18/2016	32.173268	-80.900371	13:00	2	
11/19/2016					no tracking
11/20/2016					no tracking
11/21/2016					no tracking
11/22/2016	32.168549	-80.898197	13:39	3	dead frond, sabal palm, close to original roost
11/23/2016	32.168549	-80.898197	9:34	3	same frond, different location on frond
11/24/2016			14:35		signal near location of 11/22 and 11/23 but roost not identified
11/25/2016			11:15	2	signal from the vicinity of 11/14/2016 location, likely the same tree
11/26/2016					no tracking
11/27/2016					no tracking
11/28/2016	32.168985	-80.897506	14:30	1	at original roost site, same dead frond
11/29/2016					no signal/ not found
11/30/2016					no signal/ went to 2 palmetto roosts and bat not found

LAIN 1 Roost Sites					
Date	**Lat**	**Long**	**Observation time**	**Roost #**	**Notes**
12/1/2016					no signal/ went to 2 palmetto roosts and bat not found
12/2/2016					no signal/ went to 2 palmetto roosts and bat not found
12/3/2016					no signal/ went to 2 palmetto roosts and bat not found, steady rain, heavy at times
12/4/2016					no search
12/5/2016					no signal/ went to 2 palmetto roosts and bat not found
12/6/2016					no observations
12/7/2016	32.168985	-80.897506	16:47	1	at original roost site, same dead frond
12/8/2016	32.168985	-80.897506	8:21	1	at original roost site, same dead frond
12/9/2016	32.168985	-80.897506	9:27	1	at original roost site, same dead frond
12/10/2016	32.168985	-80.897506	13:54	1	at original roost site, same dead frond
12/11/2016	32.168985	-80.897506	14:48	1	at original roost site, same dead frond
12/12/2016	32.168985	-80.897506	10:55	1	at original roost site, same dead frond
12/13/2016 -1/20/2016					no signal/ went to 2 palmetto roosts and bat not found

LAIN 2 Roost Sites						
Date	**Lat**	**Long**	**Observation time**	**Roost #**	**Notes**	
3/7/2016	32.180249	-80.896311		1	dead frond, sabal palmetto	palmetto in maritime forest, near wetland
3/8/2016	32.185659	-80.890949	13:00	2	dead frond, sabal palmetto	New tree, @ 1/2 mile from first roost, Between dusk and 22:00, bat was active but in range of receiver at all times.
3/9/2016	32.180051	-80.89573	14:30	3	dead frond, sabal palmetto	Returned to area of first roost tree, Between dusk and 22:00, bat was active but in range of receiver at all times.
3/10/2016	32.180206	-80.896619	10:30	4	dead frond, sabal palmetto	New tree, same area
3/11/2016	32.18032	-80.8966	12:00	5	dead frond, sabal palmetto	New tree, same area
3/12/2016	32.180313	-80.896627	12:00	6	dead frond, sabal palmetto	High temps @55 today. Much colder than past days. New tree, same area. Bat was still in roost at 21:30. 44 degrees, light mist.
3/13/2016	32.180313	-80.896627	12:00	6	dead frond, sabal palmetto	
3/14/2016	32.180313	-80.896627	10:30	6	dead frond, sabal palmetto	windy, cold, high in the 50s, low in the 30s in the same tree, could see bat (and band)
3/15/2016	32.180313	-80.896627	10:30	6	dead frond, sabal palmetto	windy, cold, high in the 50s, low in the 30s in the same tree, could see bat (and band)
3/16/2016	32.180313	-80.896627	9:00	6	dead frond, sabal palmetto	windy, cold, high in the 50s, low in the 30s in the same tree, could see bat (and band)
3/17/2016	32.180366	-80.896657	10:30	7	dead frond, sabal palmetto	new tree, visual confirmation
3/18/2016	32.180366	-80.896657	11:30	7	dead frond, sabal palmetto	visual confirmation
3/19/2016	32.180366	-80.896657	9:45	7	dead frond, sabal palmetto	visual confirmation

3/20/2016	32.180366	-80.896657	10:30	7	dead frond, sabal palmetto	visual confirmation
LAIN 2 Roost Sites						
Date	**Lat**	**Long**	**Observation time**	**Roost #**	**Notes**	
3/21/2016	32.180366	-80.896657	10:45	7	dead frond, sabal palmetto	visual confirmation
3/22/2016	32.180366	-80.896657	11:00	7	dead frond, sabal palmetto	visual confirmation
3/23/2016	32.180366	-80.896657	10:30	7	dead frond, sabal palmetto	visual confirmation
3/24/2016	32.180366	-80.896657	9:30	7	dead frond, sabal palmetto	visual confirmation, no signal
3/25/2016	32.180366	-80.896657	8:30	7	dead frond, sabal palmetto	visual confirmation, no signal
3/26/2016	32.180366	-80.896657	12:00	7	dead frond, sabal palmetto	visual confirmation, no signal
3/27/2016	32.180366	-80.896657	16:50		dead frond, sabal palmetto	possibly in roost 7, unable to see clearly
3/28/2016			16:00			no signal, not found
3/29/2016			8:00			no signal, not found
3/30/2016			14:30			no signal, not found
3/31/2016			15:00			no signal, not found

LAIN 3 Roost Sites						
Date	**Lat**	**Long**	**Observation time**	**Roost #**	**Notes**	
3/10/2017	32.17499	-80.905625	11:30	1	Roosting in Spanish moss cluster in water oak, @15 feet above the ground	During evening netting, bat emerged to forage @19:00. Returned to tree before 20:00 and remained there for the remainder of netting. High 77, low of 57
3/11/2017	32.17499	-80.905625	13:00	1	Roosting in Spanish moss cluster in water oak, @15 feet above the ground	high 60, low 51
3/12/2017	32.175013	-80.905573	13:00	2	Moved to adjacent pine in Spanish moss, much higher in canopy (@40 ft)	High temps @55 today. Much colder than past days. Bat was still in roost at 22:00, 43 degrees, light mist, low of 41
3/13/2017	32.175013	-80.905573	13:00	2		high 53, low 41
3/14/2017	32.17499	-80.905625	11:00	1	in large clump of Spanish moss in the water oak	high 57, low 43
3/15/2017	32.17499	-80.905625	11:00	1	in large clump of Spanish moss in the water oak	high 48, low 34
3/16/2017	32.17499	-80.905625	9:00	1	in large clump of Spanish moss in the water oak	high 52, low 34
3/17/2017	32.17499	-80.905625	11:00	1	in large clump of Spanish moss in the water oak	high 60, low of 33
3/18/2017	32.17499	-80.905625	12:00	1	in large clump of Spanish moss in the water oak	high 75, night low of 51
3/19/2017	32.17499	-80.905625	13:00	1	in large clump of Spanish moss in the water oak	hole in moss, visual confirmation, previous night low of 53.
3/20/2017	32.17499	-80.905625	11:00	1	in large clump of Spanish moss in the water oak	visual confirmation

LAIN 3 Roost Sites						
Date	**Lat**	**Long**	**Observation time**	**Roost #**	**Notes**	
3/21/2017	32.17499	-80.905625	9:15	1	in large clump of Spanish moss in the water oak	visual confirmation
3/22/2017	32.17499	-80.905625	10:00	1	in large clump of Spanish moss in the water oak	
3/23/2017	32.17499	-80.905625	9:45	1	in large clump of Spanish moss in the water oak	no signal, visual confirmation
3/24/2017	32.17499	-80.905625	15:00	1	in large clump of Spanish moss in the water oak	no signal, visual confirmation
3/25/2017	32.17499	-80.905625	9:00	1	in large clump of Spanish moss in the water oak	no signal, visual confirmation
3/26/2017	32.17499	-80.905625	11:15	1	in large clump of Spanish moss in the water oak	no signal, visual confirmation
3/27/2017	32.17499	-80.905625	15:45	1	in large clump of Spanish moss in the water oak	no signal, visual confirmation
3/28/2017			16:30		no signal, no visual confirmation	
3/29/2017			10:00		no signal, no visual confirmation	
3/30/2017			15:00		no signal, no visual confirmation	
3/31/2017			15:25		no signal, no visual confirmation	

MYAU 1 Roost Site				
Date	**Lat**	**Long**	**Observation time**	**Notes**
9/29/2016	32.179482	-80.896508		sweet gum (opening at base) in mixed hardwood/pine forest
9/30/2016	32.179482	-80.896508		sweet gum (opening at base) in mixed hardwood/pine forest
10/1/2016	32.179482	-80.896508	12:42	sweet gum (opening at base) in mixed hardwood/pine forest
10/2/2016	32.179482	-80.896508	15:28	sweet gum (opening at base) in mixed hardwood/pine forest
10/3/2016	32.179482	-80.896508	17:30	sweet gum (opening at base) in mixed hardwood/pine forest
10/4/2016	32.179482	-80.896508	9:10	sweet gum (opening at base) in mixed hardwood/pine forest
10/5/2016				evacuation for hurricane Matthew
10/6/2016				evacuation for hurricane Matthew
10/7/2016				evacuation for hurricane Matthew
10/8/2016				evacuation for hurricane Matthew
10/9/2016				evacuation for hurricane Matthew
10/10/2016				evacuation for hurricane Matthew
10/11/2016				evacuation for hurricane Matthew
10/12/2016				site inaccessible due to hurricane damage
10/13/2016				site inaccessible due to hurricane damage
10/14/2016				site inaccessible due to hurricane damage
10/15/2016				site inaccessible due to hurricane damage
10/16/2016				site inaccessible due to hurricane damage
10/17/2016				no signal but tree undamaged from storm

Appendix B

Species from Feces Results

NORTHERN ARIZONA UNIVERSITY

School of Forestry

Species from Feces Results

Client:	Mary Socci, Palmetto Bluff Conservancy, MSocci@pbconservancy.org
Samples:	We received a hair sample and fecal pellet of a captured bat from South Carolina.
Sequencing:	16 November 2016
Report date:	17 November 2016
Results:	The hair sample was sequenced using traditional Sanger methods, and was identified as from *Myotis septentrionalis*. None of the negative controls amplified or sequenced. The fecal sample was not salvageable.

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